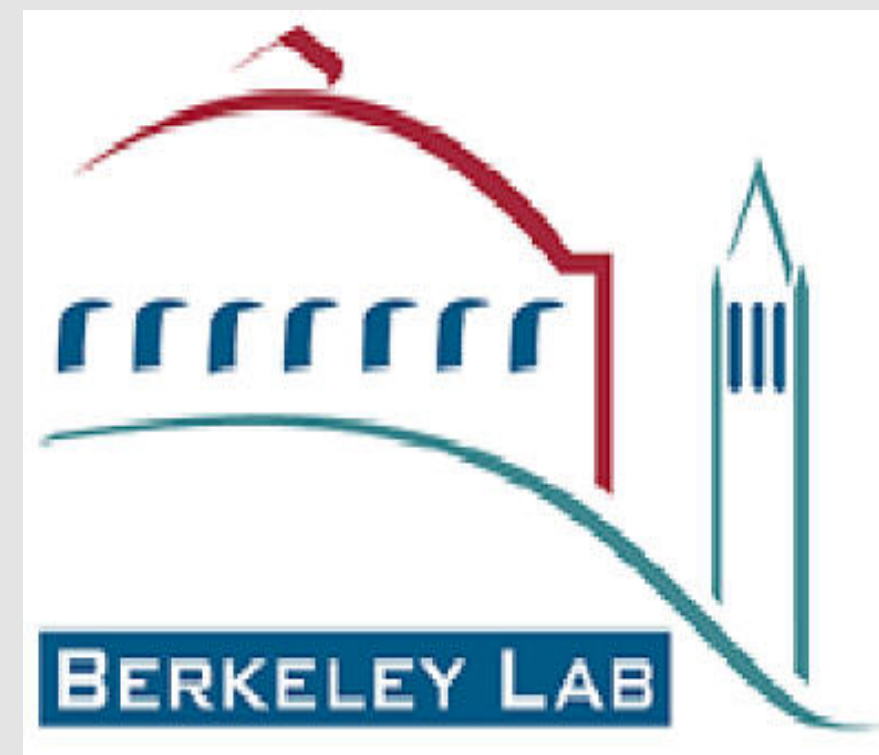


# Nuclear Modification Factors of $D^0$ Meson in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV

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STAR

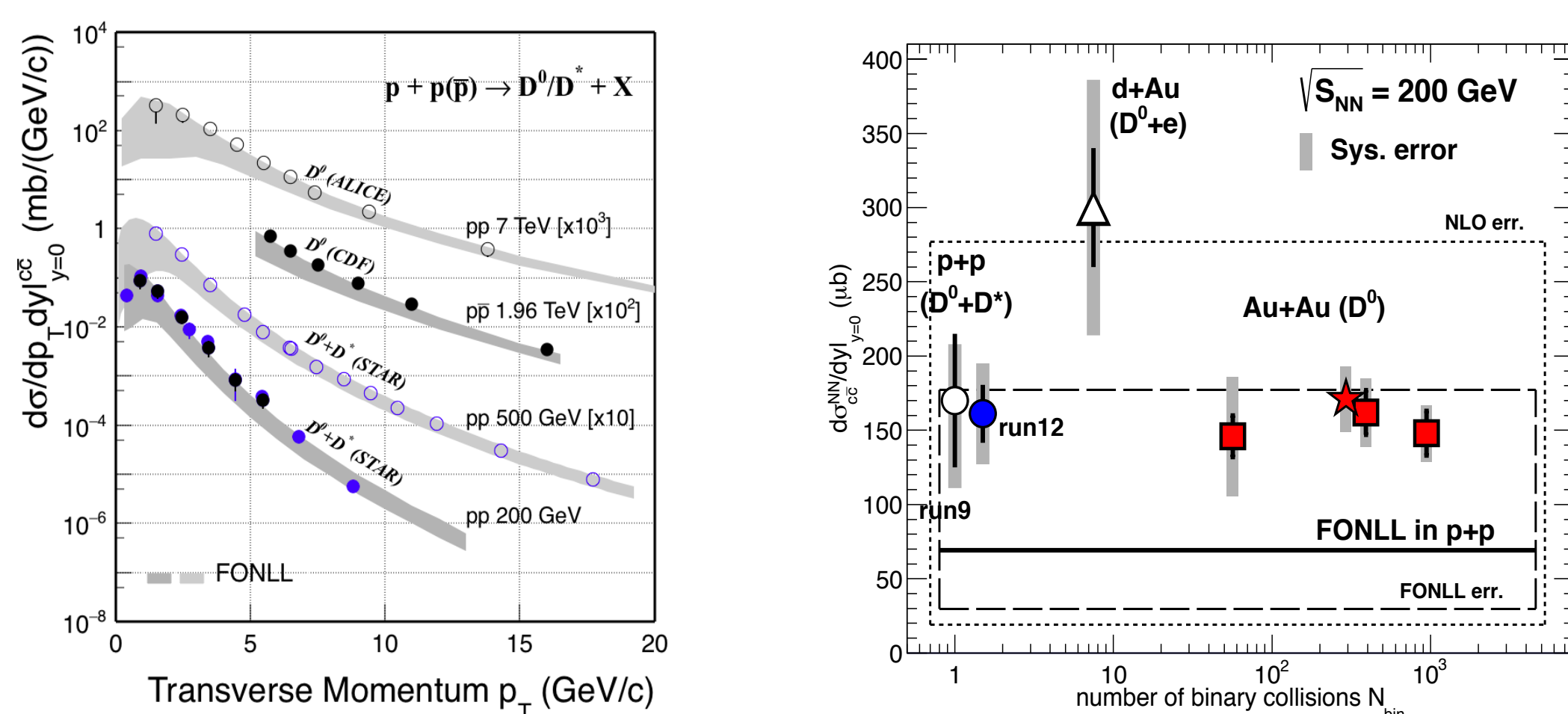


## Abstract

Heavy-flavor quarks are dominantly produced in initial hard scattering processes and experience the whole evolution of the system in heavy-ion collisions at RHIC energies. Thus they are suggested to be an excellent probe to the medium properties through their interaction with the medium. In this presentation, we report our first measurement of  $D^0$  production via topological reconstruction using STAR's recently installed Heavy Flavor Tracker (HFT). We also report our new measurement of Nuclear Modification Factor ( $R_{AA}$ ) of  $D^0$  mesons in central Au+Au collisions at  $\sqrt{s_{NN}} = 200$  GeV as a function of transverse momentum ( $p_T$ ). New results confirm the strong suppression at high  $p_T$  with a much improved precision, and show that the  $R_{AA}$  at high  $p_T$  are comparable with light hadrons ( $\pi$ ) and with D meson measurements at the LHC. Furthermore, several theoretical calculations are compared to our data, and with charm diffusion coefficient  $2\pi TD_S \sim 2-12$  can reproduce both the  $D^0 R_{AA}$  and  $v_2$  data in Au+Au collisions at RHIC.

## Motivation

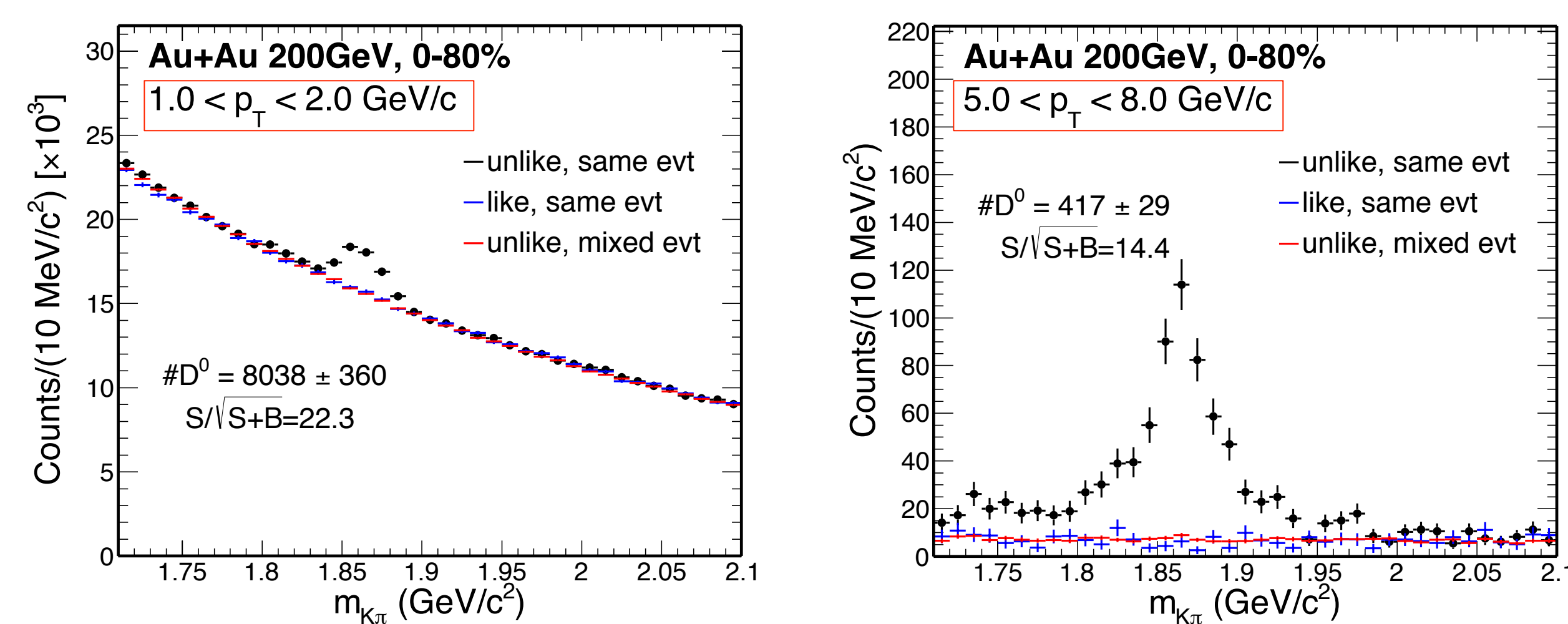
- The mass of Charm quarks are heavy,  $m_c \gg T_C, \Lambda_{QCD}, m_{u,d,s}, T_{QGP}(RHIC/LHC)$
  - They Produced early in collision at RHIC through hard scattering
  - Experience the whole evolution of the system
- Good probe for medium properties



- Perturbative QCD calculations (FONLL) are consistent with experimental data
- Charm cross section follows number of binary collisions scaling

## $D^0$ Meson Signals and Efficiency Correction

- Clean  $D^0$  signals reconstructed with significantly enhanced signal-to-background ratios with the HFT in a broad range of transverse momentum

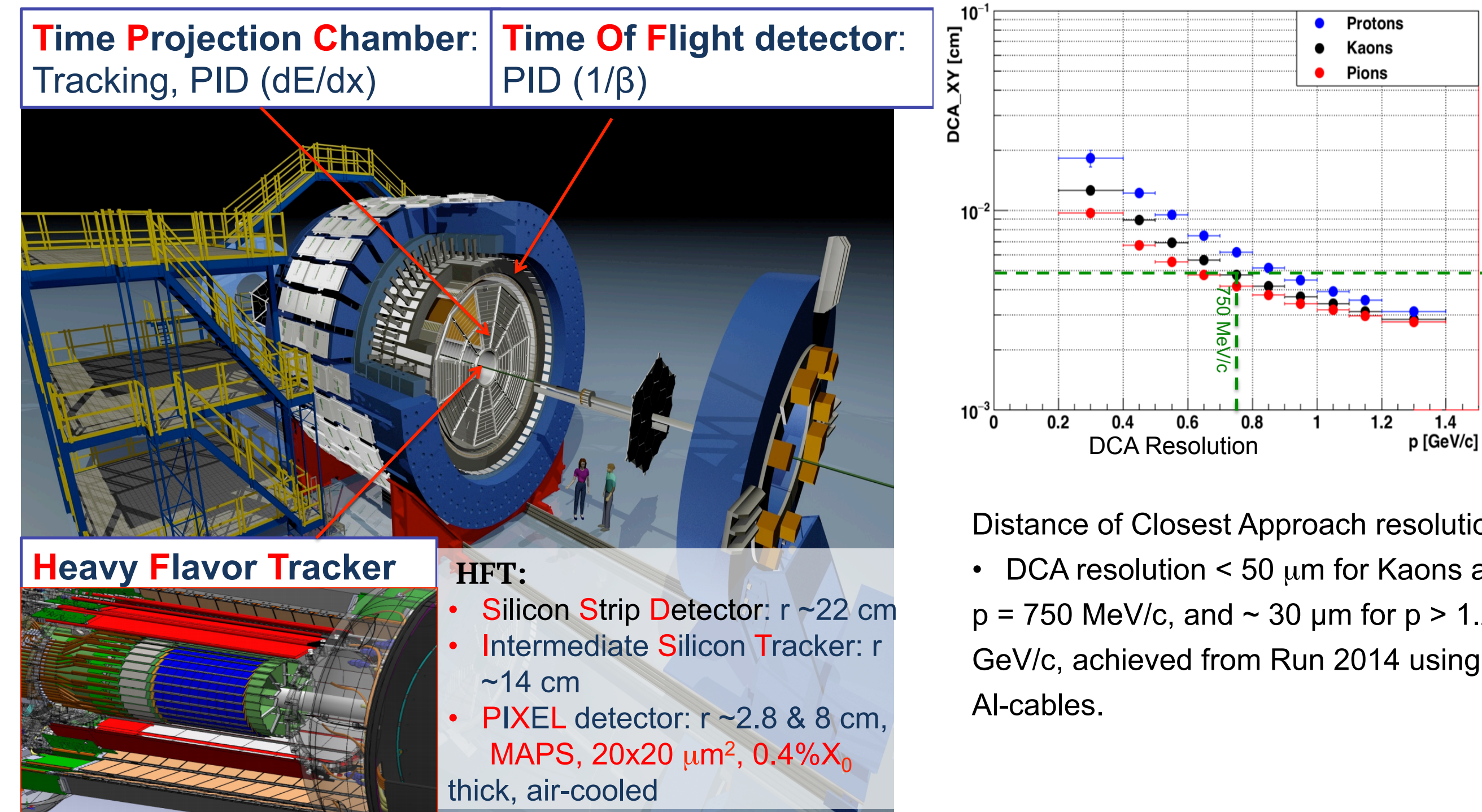


- $D^0$  efficiency correction (Data-Driven Fast Simulation)

Efficiency = TPC tracking eff  $\otimes$  HFT tracking eff  $\otimes$  topological cuts

- HFT matching and resolution smearing using distributions extracted from data:
  - HFT eff.  $\times$  geometrical acceptance: (HFT matched tracks) / TPC tracks.
  - Spatial resolution: DCA distributions of HFT matched tracks (XY-Z dependence).
  - Luminosity, centrality, azimuth and pseudo-rapidity dependence have been considered.
- Embedding
  - Full STAR GEANT simulation
  - MC embedded in real raw data + data reconstruction chain
- Fast Simulation package was validated by Full GEANT simulation

## STAR Detector and HFT Performance



Distance of Closest Approach resolution

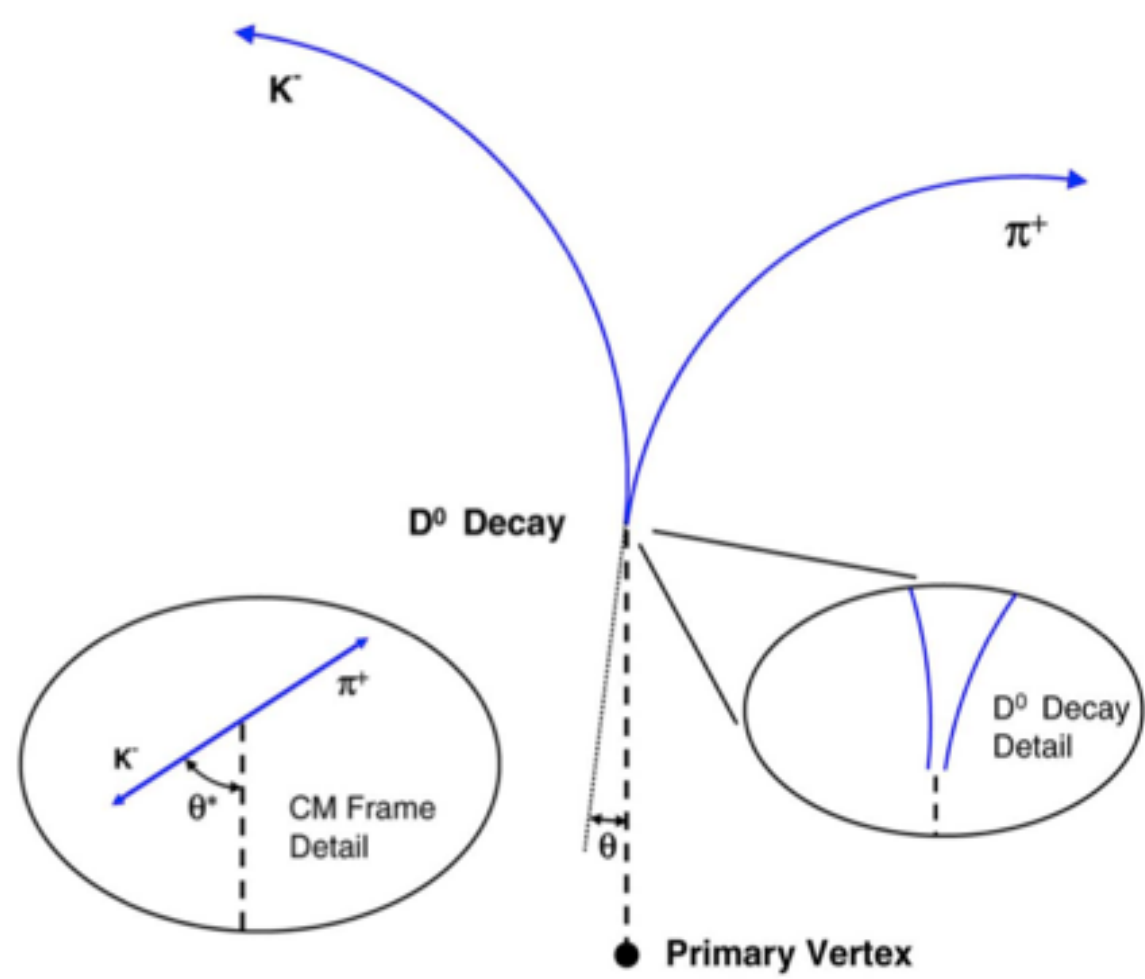
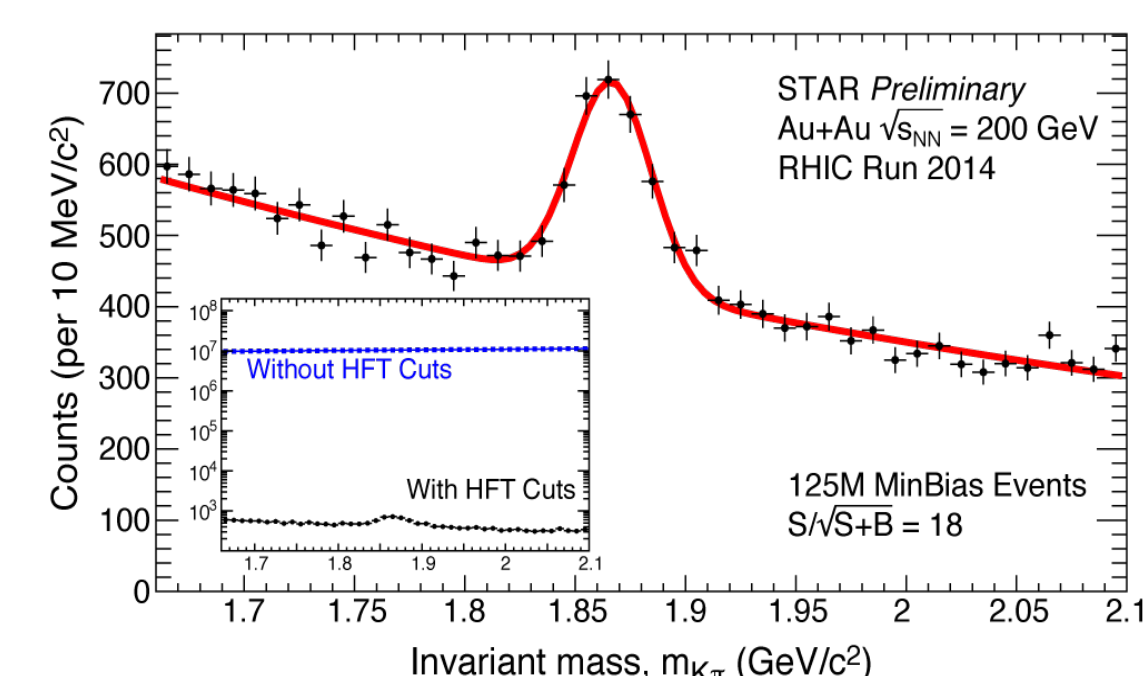
- DCA resolution  $< 50 \mu m$  for Kaons at  $p = 750$  MeV/c, and  $\sim 30 \mu m$  for  $p > 1.2$  GeV/c, achieved from Run 2014 using Al-cables.

## $D^0$ Meson Reconstruction

Direct topological reconstruction through hadronic channel:

$$D^0(\bar{D}^0) \rightarrow K^+ \pi^- (BR \ 3.89\%)$$

$c\tau \approx 120 \mu m$



$D^0$	w/o HFT	with HFT
Year	2010 + 2011	2014
# Events (MB) analyzed	1.1 B	780M
Significance per billion events	13	$\sim 220$

With HFT, can greatly reduced combinatorial Background

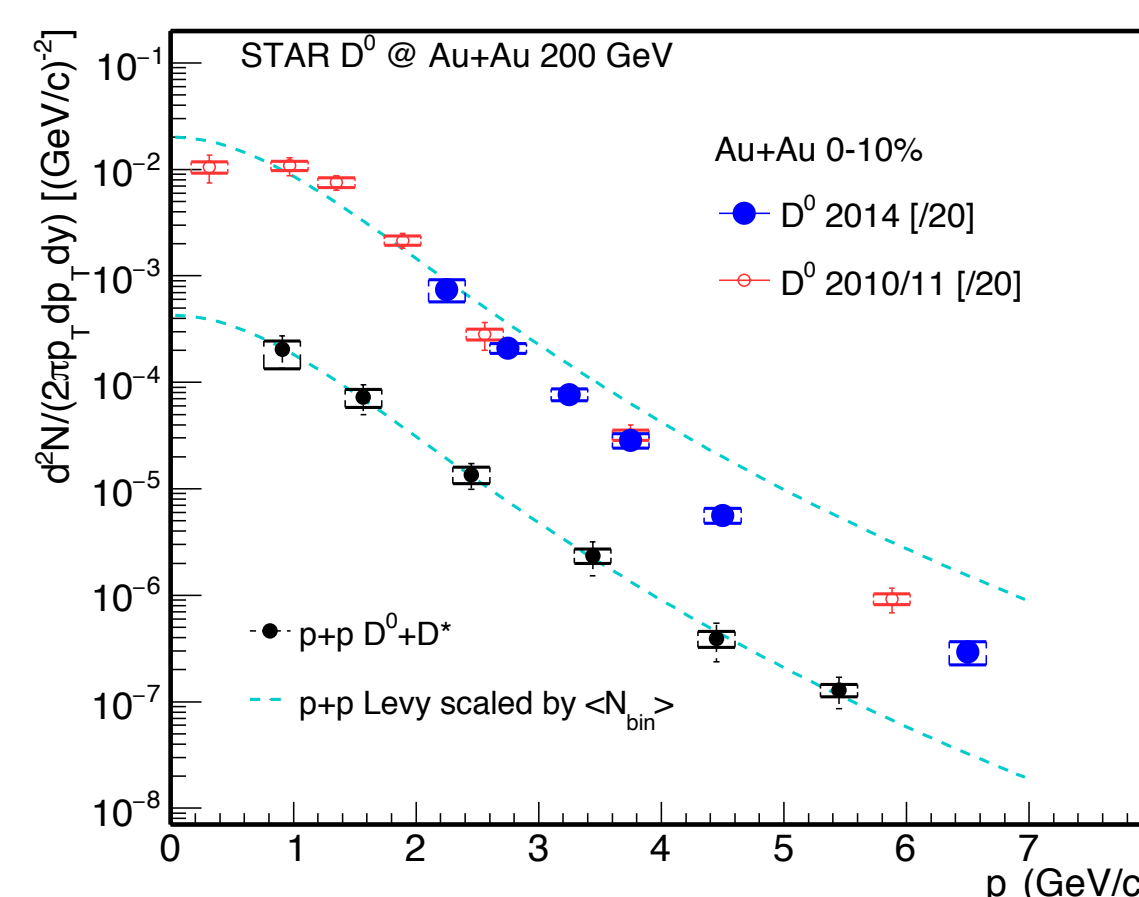
Topological cuts optimized by TMVA (Toolkit for Multi-Variate Analysis)

## Summary and Outlook

- First measurement of  $D^0 R_{AA}$  using STAR HFT
- $D^0$  spectra and  $R_{AA}$  with HFT in full  $p_T$  and peripheral Au+Au collisions
- 2 Billion Au+Au events from Run16 with further improve our precision

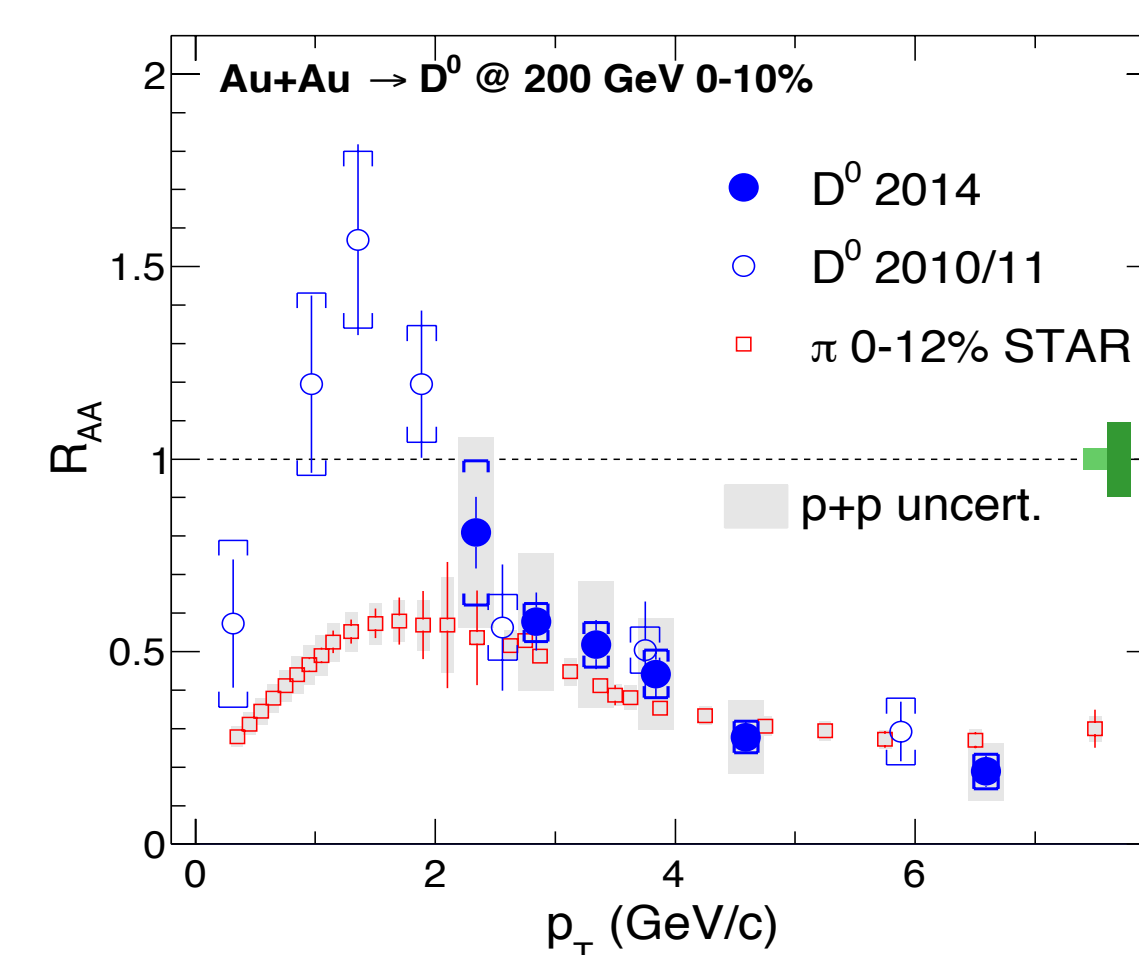
## Results

Ref: STAR: PRL 113 (2014) 142301  
PLB 655 (2007) 104



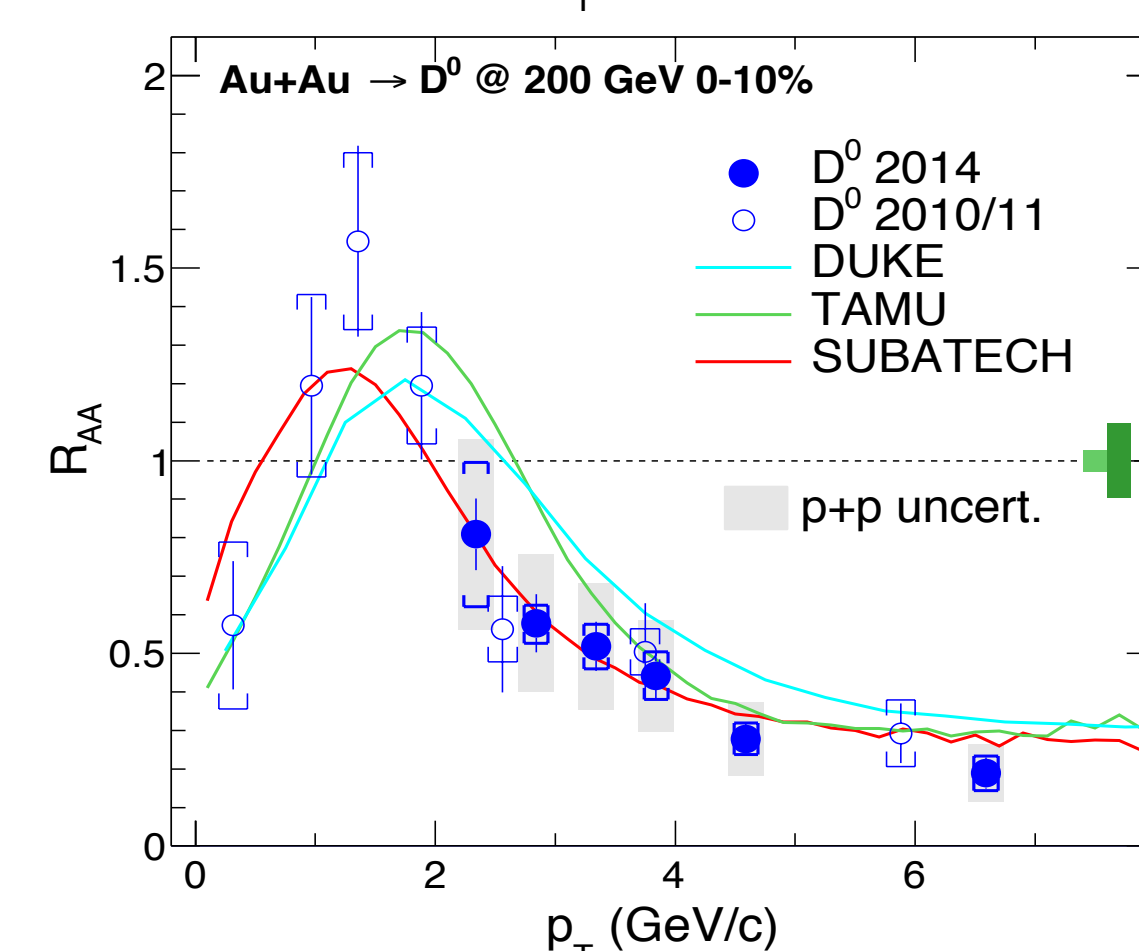
### 1, Invariant Yields

- [High  $p_T$ ] Consistent with published result, with improved statistical precision
- Finalizing systematic uncertainties for  $p_T < 2$  GeV/c and in peripheral collisions



### 2, Nuclear Modification Factors

- [High  $p_T$ ]: Significant suppression in central Au+Au collisions. New results have improved precision
- $R_{AA}(D) \sim R_{AA}(\pi)$  at  $p_T > 4$  GeV/c  
Similar energy loss for light partons and charm quarks at high  $p_T$
- $p+p$  precision to be improved using 2015 data



### 3, Comparison to Models

- DUKE: Langevin simulation, input parameter  $2\pi TD_S = 7$  (tuned to the LHC data)
- TAMU: non-perturb.,  $2\pi TD_S = 2-10$
- SUBATECH: MC@shQ calculation with latest EPOS3 initial conditions,  $2\pi TD_S = 2-4$
- Good agreement between model and experiment data with  $2\pi TD_S = 2 \sim 12$